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W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

The following candidates were proposed as Fellows of the Society, the name of the proposer from personal knowledge being appended :—

Alfred Fowler, Demonstrator of Astronomical Physics, Normal School of Science, South Kensington (proposed by J. Norman Lockyer) ;

Joseph Kleiber, Privat-Docent of the University of St. Petersburg, 53 Gr. Morskaia, St. Petersburg (proposed by J. W. L. Glaisher) ;

David Smart, L.R.C.P., M.R.C.S., L.S A., 108 Grange Road, London, S.E. (proposed by W. S. Franks).

The Photographic Spectrum of the Nebula of Orion.
By Dr. W. Huggins, LL.D., D.C.L., F.R.S.

(*Extract from a letter to Mr. Knobel.*)

"By photographs I have obtained nearly thirty new lines, and, what is perhaps of most interest, is that there are at least three groups of lines in the spectra of two of the stars of the trapezium which certainly extend, some more than others, into the adjoining nebular matter, and so show that these stars are not merely optically, but truly and physically connected with

the nebula. In another photograph taken a little distance from the trapezium, some of these lines appear to be absent, which suggests there may be a difference in the nebular spectrum in the *photographic region* (though not in the visible spectrum) between different parts, possibly more or less condensed, of the nebula. The bad weather prevented me from working out this point, and it is not more than a suggestion.

"The position of the brightest line which my former observations in 1864, 1871, and 1873 had fixed with great exactness, does *not* agree with that of the first line of the magnesium-flame band. I took very great pains during the winter to make a *direct comparison* of burning magnesium with the spectrum of the nebula: the result came out to confirm my early observations, and to show that the line of magnesium-flame band is *not* coincident with the line of the nebula.

"I therefore come to the provisional conclusion that so far as we know the nebula now is in a *state of gas*, though we have no knowledge of the *anterior* conditions which have brought it into this state."

The Spectrum of Uranus. By Dr. W. Huggins, LL.D., D.C.L., F.R.S.

(*Extract from a letter to Mr. Knobel.*)

"You may like to know an interesting new result I have just got. I have succeeded by photography in solving the question of solar lines in the spectrum of *Uranus*. With an exposure of two hours I got on June 3 a fine spectrum from about F to N in the ultra-violet. On the same plate a solar spectrum is photographed for comparison. In the spectrum of the planet all the principal Fraunhofer lines are distinctly seen, and I am unable to distinguish any other lines bright or dark. It is certain, therefore, that the light of the planet, for this region of the planet at least, is *solar*.

"In 1871 I sent a paper to the Royal Society, on the visible spectrum of *Uranus*, and gave a map and measures of six dark bands. I was unable, probably on account of the feebleness of the light, to catch the solar lines. In 1872 Vogel worked on the spectrum. He observed my bands, and he also failed to see any Fraunhofer lines." The weather since has not permitted me to observe again the *visible* spectrum.

The Spectrum of Saturn.

Before last week I took a number of spectra of *Saturn* and his rings. The slit so placed that the ansæ, ball and ring crossing it, give *separate* spectra, and the planet kept so absolutely on

the same part of the slit, that these spectra remain distinct, without encroaching on each other. I photographed *Saturn* in 1881, but as I saw Fraunhofer lines only I did not describe it. In my recent photographs the solar lines are well seen, and in these spectra, from about F to N, I am unable to detect any other lines bright or dark. *Saturn* was photographed before it was dark so as to give a very faint sky-spectrum for comparison.

Observations of the Spectrum of Uranus. By Albert Taylor, A.R.S.M., A.N.S.S.

(*Communicated by A. A. Common, F.R.S.*)

On Thursday, May 16, 1889, bright flutings were detected in the spectrum of the planet *Uranus*, by means of a small direct-vision star spectroscope, attached to the 5-foot reflector at Mr. Common's observatory at Ealing. The abundance of light obtained by the great aperture has allowed a more powerful spectroscope to be used since that date, micrometric measurements have been made of the positions of these flutings and bands, and of the dark bands in the spectrum of the planet, and the wave-lengths obtained by the reduction of these measurements are submitted to the Society in this paper.

Professor J. Norman Lockyer had telegraphed early in the month asking for the spectrum to be examined for bright flutings, and on first examination with the 5-foot the most striking features seen were four broad dark bands in the orange, green, greenish-blue, and blue respectively, and between these a series of bright flutings and bands, some of which were sharpest towards the red and others towards the blue end of the spectrum. This compound spectrum was also seen by Mr. Fowler, the demonstrator of astronomy at the Science Schools, South Kensington, who was on a visit to Ealing on May 16. The second dark band from the red end was seen to be the broadest, and was very strong, it and the narrower fourth band (the one in the blue about F) being very much darker than the remaining two. No trace of any solar line or of any narrow line in the spectrum was visible, although the spectrum was very bright, and the slit of the spectroscope was sufficiently narrow to show D as one sharply defined line in a Bunsen's burner (the dispersion being just sufficient to divide the D lines when the narrowest slit is used). As no measurements could be made with any degree of accuracy, and comparisons were difficult, independent light curves were drawn, and on comparison these were found to agree in all the main features. The curves are given in the drawing, and it will be seen that the four dark bands agree in relative position and width; the brightest part of the spectrum

is shown by each as in the green (subsequent measurements of positions giving 5190 as the wave-length), and two other great maxima are in perfect agreement. The only discrepancy between the two curves is in the yellow, and this was cleared up by observations at a later date. There are four submaxima indicated in my curve that Mr. Fowler omitted in his, but they were only seen with great difficulty and after resting the eye for some time.

On May 18 I was able again to observe the spectrum with the direct-vision spectroscope, and to confirm the light curve drawn on the 16th, with the exception of the region of previous discrepancy in the yellow, which I found should be as shown in the third curve. Several comparisons were also tried. The brightest fluting of carbon (517) was found to be nearly, but not exactly, coincident with the brightest fluting in the spectrum of *Uranus*, and the other carbon flutings (564 and 474) were seen to be very near bright flutings in the planet. The D lines of sodium fall near a faint dark band, but there is no dark marking or line of any kind exactly at that position in the spectrum of *Uranus*, neither was any other solar line visible, although fine lines were specially searched for. In the blue the spectrum was noted as faint and difficult to observe and represent, the bright bands sometimes appearing separated from the continuous spectrum. Several faint dark bands were seen in addition to the four broad absorptions.

On May 20 and 21, micrometric measurements were made of the dark bands and of the bright flutings and bands. The spectroscope used has one prism of 60°, and two of 30°, with automatic adjustment for minimum deviation. The collimator and observing telescope lenses are 1-inch aperture and $5\frac{1}{2}$ inches focus. The angular dispersion from A to H is 5°, and the eye-piece used magnifies fifteen times. The micrometer has a screw of 100 threads to the inch, and the drum is divided into 100 parts, so that accurate measurements can be made to $\frac{1}{10000}$th of an inch.

With this spectroscope ten dark bands were seen and measured, five of these being very strong absorption bands. Fourteen bright bands and flutings were seen, the positions of twelve of them measured, and a light curve was drawn to show their relative brightness. On no occasion was any narrow line seen, the solar spectrum being found to be entirely absent, although the slit was adjusted to show the b lines divided in the spectrum of magnesium, and narrow lines were specially looked for in the spectrum. The wave-lengths of the limits of the broad dark bands and of the middle of each of the fainter dark ones and of the brightest portions of the bright bands are as follows:—

Dark Bands in the Spectrum of Uranus.

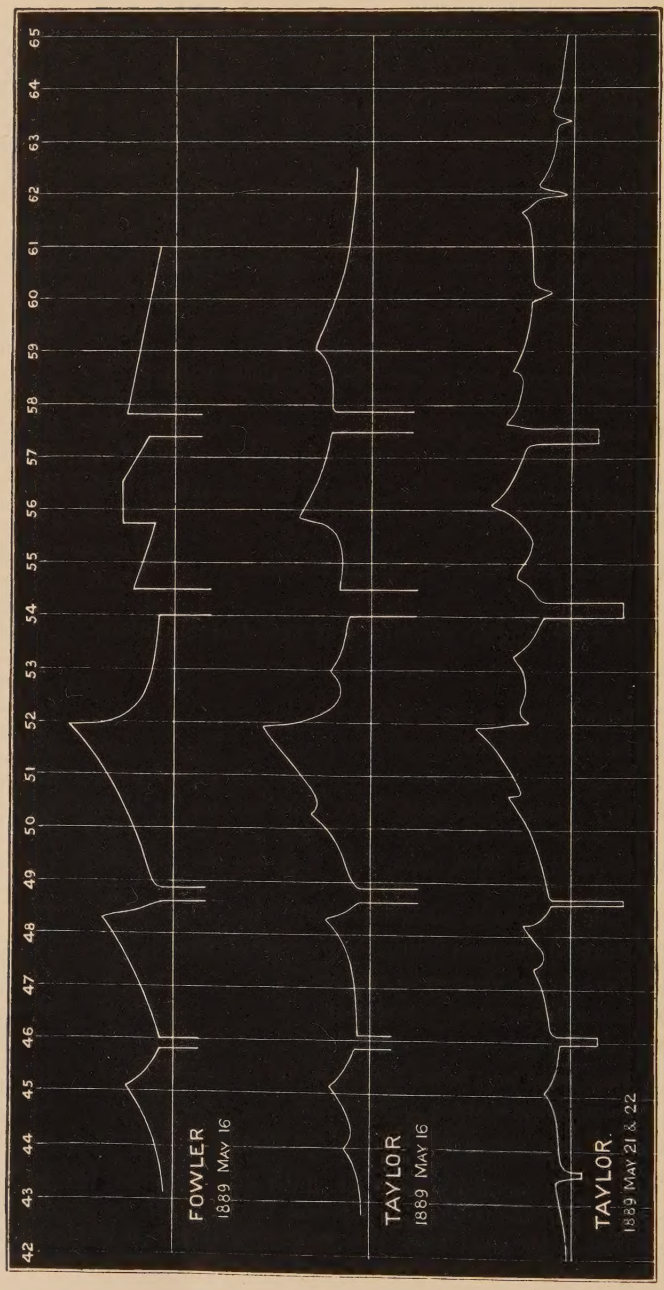
		Wave-lengths.
I.	Very faint dark band	... 6332
II.	Dark band stronger and broader than I.	... 6194
III.	Very faint band (broad)	... 6010
IV.	Very strong band, very broad and apparently of unequal intensity	Begins 5754 Max. 5740 Ends 5730
V.	Very faint and narrow, and close to a bright fluting	... 5543
VI.	Broad band, of equal intensity throughout ...	Begins 5428 Ends 5399
VII.	Rather narrow band at red edge of brightest fluting	Begins 5210 Ends 5200
VIII.	Strong rather broad band of equal intensity throughout	Begins 4868 Ends 4860
IX.	Fairly strong broad band, not so dark as either VIII., VI., or IV.	Begins 4614 Ends 4594
X.	Another faint band, very difficult to measure ...	Begins 4350 Ends ?

The wave-lengths are means of two determinations.

Bright Bands and Flutings.

		Wave-lengths.
I.	Bright fluting, fading towards blue	6170
II.	Bright band, fainter on red edge	5863
III.	Brightening at edge of a dark band, fades towards the red	5761
IV.	Very strong bright band, fairly sharp towards the blue, and fading slightly towards the red	5601
V.	Strong bright band, fading both ways, but most towards the red	5473
VI.	Faint bright band, fading out equally in both directions ...	5302
VII.	Brightest, strongest fluting, sharp on its red edge ...	5190
VIII.	Faint fluting, sharp on its red edge	5068
IX.	Strong fluting, sharp towards red	4826
X.	Faint fluting, sharpest on red edge	4741
XI.	Faint broad band fading both ways, but sharpest to the red	4510
XII.	Faint fluting, sharpest to red	4345
XIII.	Faint band seen occasionally, but not measured... about	4100

There is decidedly another fluting similar to II. in the extreme red (about 635), but it was too faint to be accurately measured. In each case the wave-length given is the mean of three determinations.



Light Curves of the Spectrum of *Uranus*.

Although the term "fluting" is used, it must not be taken as implying that any structure was seen in these bright bands, but rather that the band was sharper at or near one edge than the other. The light curve of the spectrum of *Uranus* has been checked on four nights since May 21, and the drawing of that date confirmed.

On May 21 Mr. Espin, observing at Wolsingham Observatory with his 17¼-inch reflector, saw the blue broken up into bright bands and dull shadings, but found it impossible to give the places of these details, if they exist, in a drawing. He was using two compound prisms before an eyepiece of 200 power. Definition good but twilight, and planet low. On May 31 Mr. Crossley saw the spectrum of *Uranus* in the direct-vision spectroscope on the 5-foot reflector at Ealing, and saw most decided bright flutings in the green, yellow, and red, but was not so positive about the blue end of the spectrum. Mr. Bicknell, on June 3, also saw the bright flutings in the green, yellow, and red.

Of course it is an exceedingly difficult matter, and one requiring the utmost care, to distinguish between a bright band and a contrast appearance when a spectrum contains broad dark bands, but the bright flutings in *Uranus* are quite distinct from contrast appearances, and are so prominent as to be unmistakable.

I find Dr. Huggins and Dr. Vogel, although they measured the positions of the dark bands, do not seem to have noticed the bright flutings; but Secchi, in his light curve, seems to have had a distinct impression of the brightest fluting. This latter is more marked in his drawing of the light curve of the spectrum of *Neptune*.

The presence of bright flutings in the visual spectrum of *Uranus*, and the absence of any trace of the solar spectrum (on which point all observers agree), indicate that we must considerably modify our ideas as to the physical condition of this planet (and most probably of *Neptune* also), for there can be very little doubt that it is to a large extent self-luminous. It is interesting, perhaps, in this matter to call attention to the fact that *Uranus* is of about the sixth magnitude, yet the photometric intensity of the light of the Sun at *Uranus* is only about $\frac{1}{360}$th of that at the surface of the Earth. Of course we know nothing whatever of the reflecting power of *Uranus*, but if the light is entirely solar the absence of solar lines in the fairly bright visual spectrum will be difficult to explain, whereas if the light is to a large extent intrinsic this absence is fully accounted for.

Comparison of the Spectrum, between C and D, of a Sun-spot, observed May 27, 1884, with another of May 7, 1889. By Rev. S. J. Perry, D.Sc., F.R.S., and Rev. A. L. Cortie.

As the observations of the spectra of sun-spots at the red end of the spectrum have been rare during the time of minimum, we give in the present paper the results obtained on May 6 and 7 of the present year. All the lines between D and *w.-l.* 6474·85, very near C, were carefully examined, and their widening estimated in tenths of the normal breadth of the respective lines. The instrument used was the Browning automatic spectroscope, a dispersion of twelve prisms of 60° being employed. The definition was good, and the lines were all identified on Ångström's map. The spot had appeared on the limb on May 5, and disappeared about the 11th. The general absorption on the 6th was moderate, and on the 7th the spot was evidently breaking up. The following table contains a comparison of these observations, with the spectrum of a sun-spot near the epoch of spot maximum, taken under precisely the same conditions on May 27, 1884. This latter spot was very black, with a dark general absorption. Its spectrum had been previously observed on April 4, and it had reached its quiet stage after two solar revolutions. In Table I. the first column gives the wave-lengths of the lines taken from the British Association Catalogue (1878), and in the second and third columns are the observed amounts of widening in the two spots. The lines seen bright in the chromosphere by Professor Young are marked by an asterisk. In the remarks, A., B., F., S., K., L. and D. refer to the maps and numbers of Ångström, Burton, Fievez, Piazzi Smyth, Kirchhoff, Liveing and Dewar. In Table II. are collected the results for the different metals. In drawing up this table the coincidences have been taken from Ångström's map, and the British Association Catalogue (1878). A few lines also have been admitted from Watts' Index of Spectra, when the positions were very close, always less than one tenth-metre.

TABLE I.

Lines between C and D observed in two Sun-spots.

Wave-length.	1884, May 27.	1889, May 6 and 7.	Remarks.
6562·10 C	0	0	
45·40	0·4	...	
*15·80	0·5	...	
11·64	...	...	
6498·25	0·6	...	
*96·31	0·4	...	

Wave-length.	1884, May 27,	1889, May 6 and 7.	Remarks.
94·18	...	...	
92·41	0·4	...	
90·07	0·4	...	
81·18	0·5	...	
79·01	0·5	...	Comparison of the two spots begins.
74·85	...	0·8	
71·85 70·75	0·3	1·0	Seen as single.
68·78	0·5	1·0	
67·14	0·3	...	
63·74	0·8	...	
*61·98	0·4	1·0	A basic line. Resolved by L. and D. *Fe* the less refrangible. F. resolves. Seen as double with 12 prisms.
*54·0	0·5	0·8	A double.
	1·0	...	Faint line.
49·29	0·4	1·0	*Ca* more refrangible: L. and D.; F. resolves.
38·35	0·4	0·7	*Cd* more refrangible: L. and D.; F. does not resolve.
31·73	...	0	
*30·12	0·2	1·0	
20·63	0·2	0·6	
19·17	0·3	0·6	
*15·90	0·5	0·3	
14·10	0·5	0·3	
10·62	0·5	0·5	
07·38	0·4	0·5	*Fe* more refrangible: L. and D.; F. resolves. Seen as double with 12 prisms.
		0·8	Faint line.
		0·8	Faint line.
*6399·28	0·3	0·5	
		0·5	A double, about 6383·5 F.
*92·87	0·2	0·5	Both F. and S. draw as a double. Often so seen.
79·99	0·4	0·3	
77·58	0·3	...	
	0·6	...	Probably F. 6369·5.
64·49	0·7	0·3	In A.'s catalogue. Not in his map.
61·41	0·5	0·3	
57·92	0·3	0·2	
54·28	0·3	0·2	

Wave-length.	1884, May 27,	1889, May 6 and 7.	Remarks.
		1·0	A double.
*6346·34	0·3	0·4	
43·40	0·2	0·5	
38·21	0·2	0·3	
36·61	0·2	0·3	
34·54	0·2	0·3	
	0·8	1·0	Not in A.
	0·7	1·0	Not in A. Probably B. 6327·0.
21·81	*d*	0·5	Only darkened May 27, 1884.
18·41	0·4	0·3	
17·17	0·4	0·6	
14·18	0·4	0·4	
09·78	0·5	0·5	May 6, 1889. Double or triple. A. draws as a faint line.
05·0	...	0·5	Wave-length doubtful. A double. F. has the line.
01·88	1·0	0·3	Black and close double.
01·03	0·1		
00·5	...	0·3	In A.'s map. Not in his catalogue.
6298·74	0·4	0·3	
96·95	0·4	0·5	
	d	...	Probably K. 801·5. Darkened May 27, 1884.
94·27	0·4	0·4	A double. A. has a line at 6293·5 in his map.
91·78	0·3	0·5	
90·31	0·3	0·4	
86 69	0·8	0·2	
84·99	1·0	0·6	
81·81	0·6	0·8	May 6, 1889. Three well-marked lines seen in the α group, surrounded by a hazy band.
79·79	0·5	0·8	
77·09*a*	0·3	0·4	
76·32?	1·0	1·0	A faint line just preceding a group.
70·16	*d*	0	
69·35	*d*	0·5	
	1·0	...	
	1·0	...	
64·31	0·3	0·3	
62·68	...	...	May 6, 1889. Could not be seen at all.
60·37	0·5	...	
57·84	0·8	1·0	Close double.

Wave-length.	1884, May 27,	1889, May 6 and 7.	Remarks.
55·51	0·4	0·8	
53·40	0·4	0·8	
51·76	0·4	0·8	
46·55	0·4	0·6	
*45·62		0·6	
43·49	0·5	0	
42·60		3·0	May 6, 1889. Very much widened on more refrangible side.
40·51	0·5	1·0	Double seen as one line.
39·42			
*37·55	0·3	0·8	Triplet hard to separate in spot. Has a fuzzy appearance.
37·09			
36·33			
*6231·72	0·4	0·5	
29·91	0·2	0·6	
28·35	0·5?	1·0	
25·62	0·8	0·8	
22·57	1·0	0·8	
21·10	1·0	0·8	
*18·46	0·3	0·5	
15·67	0·5	1·0	
*14·30	0·5	0·6	
12·55	0·2	0·8	
09·3	1·0	...	A line in A.'s map, but neither in his nor B.'s catalogue. Could not be seen May 6, 1889.
	0·8	...	F 6203·5.
*6199·85	0·3	0·5	
	1·0	1·0	Faint line not in A.
*90·71	0·4	0·5	
87·26	0·8	0·8	
	0·8	0·8	6185·4 in A.'s map; not in his catalogue.
	1·0	1·0	Faint line. F 6182·0?
79·46	0·4	0·5	
75·95	0·5	0·5	
74·51	0·5	0·6	
72·49	0·2	0·5	
69·59	0·5	0·6	
*68·48	0·5	0·8	
65·62	0·8	2·0	Widened very much in penumbra, May 6, 1889.

Wave-length.	1884, May 27.	1889, May 6 and 7.	Remarks.
63·95	0·8	1·0	
62·69	0·5	0·5	
*61·40	0·3	0·6	
60·23	0·8	0·8	
56·90	0·2	0·5	
54·41 53·89 53·33	0·5	0·8	A close triplet. Difficult to separate in spots.
50·68	0·5	0·5	
	1·0	0·8	Not in A. or F.
*48·28	0·2	0·5	
*46·76	0·2	...	Line could not be seen at all, May 6, 1889.
44·09	0·2	0·8	
*40·81	0·1	0·6	
36·82	0·2	0·6	
*35·82	0·2	0·6	
	1·0	2·0	Faint spot line. Not in A. or F.
30·59	0·4	0·8	
28·61	0·2?	0·8	
27·00	0·5	0·5	
25·29	0·5	0·8	
23·92	0·2?	0·8	
*21·34	0·4	0·5	*Co* less refrangible: L. and D. F. does not resolve.
6118·93	0·5	0·8	Very faint line.
15·51	0·3	0·3	*Ni* lines sharp, thin, dark lines.
*10·11	0·5	0·8	
07·36	0·2	0·3	
04·58	1·0	0·8	
*01·92	0·4	0·6	*Ca* more refrangible: L. and D.
6099·08	0·6	0·5	
95·20	0·3	0·5	The identification of the group of faint lines between 6101·92 and 6077·8 is somewhat doubtful. A. gives ten lines, K. eleven, B. twelve, F. sixteen, and S. eighteen. With 12 prisms and excellent definition, fourteen lines have been seen, the grouping agreeing much more with the map of S. than with that of F.
92·42	0·5	...	
90·59?	0·5	1·0	
88·42	0·5	...	

Wave-length.	1884, May 27.	1889, May 6 and 7.	Remarks.
86·69	0·5	0·7	
85·1	*a*	0·5	
*84·0?	0·6	0·5	
81·3	0·5	0·5	
80·4	0·5	0·5	
77·80	0·3	0·5	F. doubles.
75·87	0 5?	...	Not seen, May 6, 1889.
*64·70	0·4	0·4	*Fe* less refrangible: L. and D. F. doubles.
	1·0	1·0	6061·7 F.
55·29	*a*	0·3	
53·28	0 8	0 8	
		1·0	Spot line 6044·79 F.
41·37	0·2	0·3	
	1·0	2·0	6039·4 F.
26·14	0·4	0·5	
23·16	0·3	0·5	
20·91	0·5	0·5	
*19·33	0 3	0·5	A double, F. 933·8 K.
15·81	0·4	0·5	
12·68	0·5	0·5	
11·42	...	1·0	
07·65	0·4	0·2	
07·2	...	0·4	B.'s catalogue. 940·4 K.
		1·0	Spot line about *w.-l.* 6004.
02·25	0·4	0·2	
	1·0	1·0	A. has a *Ti* line in map at 5998·5, but not in his or B.'s catalogue.
5997·08	0 5	0·2	
96·44	...	...	
*90·20	...	0·4	Generally not able to separate.
89·89	...		
88·10	...	0·4	A double.
86·35	0·4	0·2	
84·35	0·8	·3	
83·01	0·8	0·2	
77·27	1·0	1·0	
76·23	0·3	0·3	
74·79	0·5	0·3	
5970·44	...	0·3	
69·22	...		

Wave-length.	1884, May 27.	1889, May 6 and 7.	Remarks.
67·35	0·8	0·5	
65·9	0·8	0·5	In A.'s map, but not in his catalogue.
57·22	0·3	0·3	
55·63	...	0·5	
53·94?	...	1·0	
51·96	0·5	0·5	
47·62	0·5	0·3	
45·	...		
44·98	...	0·5	
43·62	...		
41·71	...		
40·9	...	0·5	Marked in A.'s map, but not in his catalogue.
40·43	...		
37·44	...	0·8	
34·03	0·5	0·3	
31·76	1·0	0·5	Drawn slightly out of position in A.'s map.
31·18			
29·46	0·2	0·3	
27·37	0·2	0·5	
24·02	0·5		Two lines generally seen as one thick one.
22·99		0·5	
21·69	0·5		
20·87	...	...	In A.'s map and catalogue, and in B.'s catalogue, but not seen.
19·09			
18·4	0·5	0·5	A dark band 5918·4 is not marked in A.'s catalogue, but in his map.
17·51			
14·60	0·5	0·8	
*13·30	0·2	0·1	
09·72	0·7	...	
04·56	0·5	0·2	A bright line or space about 5900. May be the effect of contrast.
5899·10	0·8	0·2	
*95·13	0·3	0·4	
92·10	0·4	0·2	
90·78	...	0·5	
*89·12	0·3	0·4	

TABLE II.

Lines widened one-half or more of their normal breadth.

Substance.	1884, May 27.	Bright in Chromosphere.	1889, May 6 and 7.	Bright in Chromosphere.
Iron	8	0	27	10
Titanium	12	1	12	2
Sodium	2	0	2	0
Calcium	3	1	8	5
Barium	2	1	4	3
Nickel	1	0	1	0
Manganese	2	0	3	0
Strontium + Fe	0	0	1	0
Cobalt + Ca	0	0	1	1
Antimony + Fe	0	0	2	1
Lithium + Ca	0	0	1	1
Cadmium + Ca	0	0	1	0
Zinc	1	0	0	0
Unknown	12	1	18	1
Unknown and faint	44	1	48	0

The above tables show that the widening of the faint unknown lines of the solar spectrum is common to the minimum and to the maximum sun-spot period. We would especially call attention to the faint lines at *w.-l.* 6039·3 F, 6053·28 A, and 6061·7 F, which are hardly traceable in the ordinary spectrum, and yet have been considerably widened in both sun-spots.

On the other hand the number of metallic lines which are among the most widened lines is much greater in the minimum than in the maximum spot. In the case of iron, for instance, the numbers are as 27 to 8. Again, none of the most widened iron lines of the maximum sun-spot have been recorded as bright in the chromosphere, while no less than ten of these lines in the minimum spot have coincident bright lines. The total number of lines seen bright in the chromosphere, which have also been observed among the most widened lines in the two spots, are for the maximum spot only five, but for the minimum spot twenty-four.

Another noticeable difference is that some lines of the maximum spot were widened far out into the penumbra, the most marked being *w.-l.* 5892·10, 5977·27, 6172·49, F. 6039·4, and F 6203·5. But in the minimum spot only one line was thus affected, 6165·62.

In Ångström's map there is a line at *w.-l.* 6209·3, of about intensity 2 of Kirchhoff's scale. This line is not in his catalogue

nor in that of the British Association, nor is it drawn in the maps of Kirchhoff, Piazzi Smyth, or Fievez. It could not be seen on May 6, and was again carefully searched for with the same result on May 21, 1889. Yet it is marked as widened in the spot of May 27, 1884.

The Nebula G. C. 2091. By E. E. Barnard, M.A., Astronomer of the Lick Observatory.

In the *Observatory* for April 1885 Mr. Sadler called attention to this nebula, and brought forward seemingly strong proof of motion. This is the nebula in which the double star *h* 2529 was observed, according to Sir John Herschel, twice in 1830 and once in 1831.

The nebula has also been observed by D'Arrest, and at Parsonstown; but it is not clear from the records that any of the observers since Herschel saw the double star to recognise it as such, though it is mentioned by them.

Mr. Burnham observed this nebula in 1879 and 1882, and measured the position-angle and distance from the tenth-magnitude star south of it. His measures are:

1879·225	8°·3	18″·96
1882·195	7°·5	18″·96

He estimated the magnitude of the star as 10, and the nebula as 12.

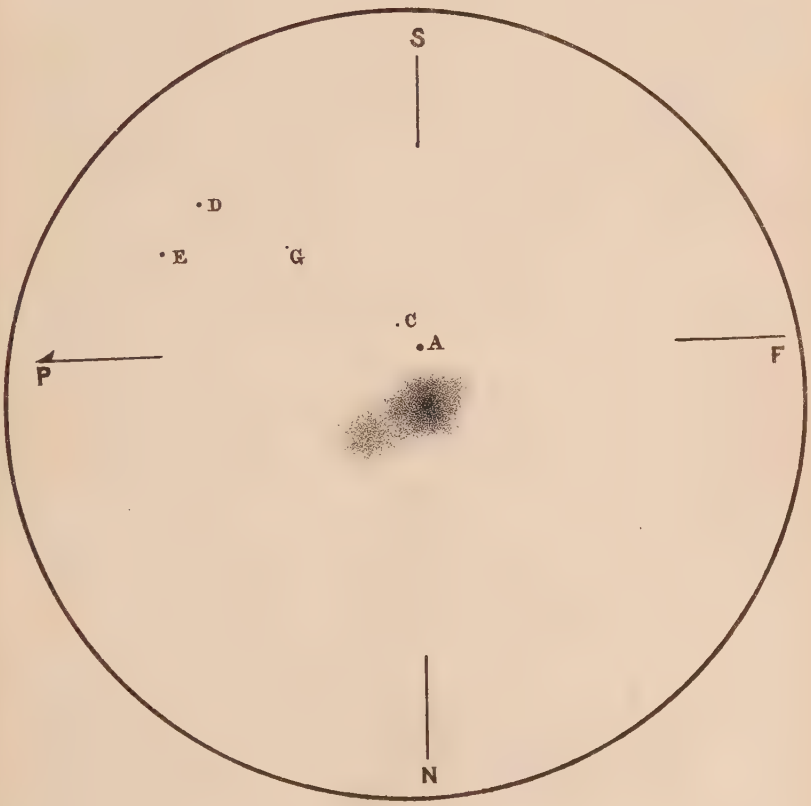
On March 5 of this year I examined the nebula with the 12-inch, and measured the position-angle and distance from the tenth-magnitude star—

1889·178 7°·8 (5 Obs.) 18″·96 (6 Obs.),

the distance coming out singularly enough the same as Mr. Burnham's two measures.

The nebula was small, round, and brighter in the middle, and quite easy to measure. I estimated the equivalent light to be of the twelfth magnitude.

On March 21, 23, and 24 Mr. Burnham and I examined this nebula with the 36-inch refractor. It was found to have an extension preceding and slightly north. This resembled a faint tail and was about 25″ long. In this extension was a faint condensation, which at first gave the appearance of a distinct nebula separated from the principal one. There was also a very faint extension for 10″ following and slightly south. Several times an excessively faint and difficult nucleus was seen, which did not appear to be stellar. A very faint star was thought to be involved in the preceding end of the tail, but it could not be seen steadily enough to make its existence certain. On each night the tenth-



The Nebula G.C. 2091, 1889 March 23.
36 inch Refractor. E.E. Barnard.

magnitude star was carefully examined by Mr. Burnham and myself; and Mr. Burnham is certain it is not now double, and that there is no double star about the nebula.

On March 23 I made a careful sketch of the nebula and of all the stars that could be seen in the field, which I here submit. The magnifying power used was 390. Some estimates were also made of the brightness of the objects shown in the sketch.

Mr. Burnham estimated A as 10th magnitude and C as 13th magnitude, which were about the magnitudes I should have assigned them. From my estimations the centre of the nebula was less bright than A, and was just perceptibly brighter than C.

The southern limit of the nebula, as near as I could estimate, was exactly one-half the distance from the nucleus to the star A. The star D is brighter than C, but less than E. The small star G is of the 14th magnitude, or fainter. No other stars besides those drawn were visible near the nebula or the star A.

In examining the region near the nebula on March 23 Mr. Burnham found a small double star $1^m\ 38^s$ *p.* and $2' \pm$ south of the nebula, which he estimates: Distance $1\frac{1}{2}''$; Pos. Ang. 160°; Mag. 8 — 11. This star is DM. + 13° 2244.

On June 7 I referred the tenth-magnitude star to the star Schj. 3813–14 with the filar micrometer of the 12-inch equatorial.

10^m * — Schj. 3813–14; $\Delta\alpha = -1^m\ 15^s{\cdot}13$ (6 Obs.); $\Delta\delta - 10'\ 7''{\cdot}5$ (3 Obs.).

This gives the place of the small star

α 1889·0 $= 10^h\ 17^m\ 48^s{\cdot}58$ δ 1889·0 $= +13°\ 7'\ 25''{\cdot}7$.

From my position-angle and distance I get

neb. — 10^m * $\Delta\alpha = +0^m\ 0^s{\cdot}18$ $\Delta\delta = +0'\ 18''{\cdot}8$,

and the resulting place of the nebula G. C. 2091

α 1889·0 $= 10^h\ 17^m\ 48^s{\cdot}76$ δ 1889·0 $= +13°\ 7'\ 44''{\cdot}5$.

On this occasion with a bright Moon the nebula was easily seen, but the star C with great difficulty. This star under favourable circumstances is easy in the 12-inch.

Whether the proper interpretation has been given to the earlier descriptions it is perhaps impossible to say, but the more recent observations do not indicate any change, and seem to justify the inference that there may be some question of the identification of the nebula, since it is wholly impossible that the double star should have disappeared absolutely, or that the nebula and star should have changed and subsequently remained fixed.

The present drawing shows faithfully all that can now be seen with the 36-inch, and will aid hereafter in deciding whether any change has really taken place.

Mount Hamilton: 1889, *June* 8.

Note on the Nebulous Star in Mr. Roberts's Photograph of 81 and 82 Messier. By Herbert Ingall.

At the April meeting of the Society some discussion ensued on the so-called nebulous star in this photograph, and the idea appeared to be put forth that it was either new or was *really* the nebula—mentioned by Sir William Herschel near 81 M., but queried in the Gen. Cat. as probably a mistaken entry of 81 M., and omitted in the new Gen. Cat. of Dreyer as certainly an error. As I have not heard of any further views on the subject I thought it might be well to try and identify the nebula. It is Gen. Cat. No. 1982 (=286 H I), and there described as "cB; cL; mbM; R. with ray." In the "Notes on Nebulæ" that I have contributed from time to time to the *Eng. Mech.*, I find that I observed it November 28, 1875, as "a moderately bright diffused nebula, 4′ *s.f.*, a bright 7 mag. star, round," and brightening to a rather condensed nucleus, but scarcely stellar; and on November 30 I say, "Dark night, nebula as above." I could detect no "ray" as mentioned by Herschel, and in a recent glance in a twilight sky the object was very diffuse and rather faint.

The extraordinary difference of its appearance in the photo-print (I have not seen the negative), and in the telescope is worthy of remark. In the latter the bright starlike aspect is entirely wanting, and it will be observed that the observations generally agree as to its aspect to the eye. D'Arrest says, October 9, 1862, only "much brighter round the middle," and again, August 12, 1866, "Subrotunda cum nucleo satis delicato ✳ 11," but whether he means a star, or equal to 11 mag. ✳, is not quite clear to me.

The place of Sir William Herschel's doubtful nebula would be near the centre of the photograph, where certainly there is no trace of nebula now.

On the Orbit of Sirius. By J. E. Gore.

The components of this interesting binary are now approaching their minimum distance, and the companion is rapidly becoming a very difficult object to measure, even with the largest telescopes. Using all the measures I could obtain from the date of its discovery by Alvan Clark, early in 1862, down to a measure made by Mr. Burnham with the Lick refractor at the close of last year, I have computed the orbit by the following method:—

Having plotted all the observations (corrected for precession to 1880·0) and drawn the interpolating curve, and the apparent ellipse in the usual way, I computed, by Professor Glasenapp's

method (*Monthly Notices*, March 1889), the values of the coefficients in the general equation of the second degree—

$$\alpha x + \beta y + \gamma x^2 + \delta xy + \epsilon y^2 + 1 = 0,$$

and obtained the following results:—

$$\alpha = -0{\cdot}001486$$
$$\beta = +0{\cdot}0067904$$
$$\gamma = -0{\cdot}00009408$$
$$\delta = +0{\cdot}0000827$$
$$\epsilon = -0{\cdot}0000677$$

These values were then substituted in Kowalsky's equations:—

$$\frac{\tan^2 i}{q^2} \cdot \sin 2\Omega = \delta - \tfrac{1}{2}\alpha\beta$$

$$\frac{\tan^2 i}{q^2} \cdot \cos 2\Omega = (\gamma - \epsilon) - \tfrac{1}{4}(\alpha^2 - \beta^2).$$

$$\frac{2}{q^2} + \frac{\tan^2 i}{q^2} = -(\gamma + \epsilon) + \tfrac{1}{4}(\alpha^2 + \beta^2).$$

$$e \sin \lambda = -\frac{q}{2}(\beta \cos \Omega - \alpha \sin \Omega) \cos i.$$

$$e \cos \lambda = -\frac{q}{2}(\beta \sin \Omega + \alpha \cos \Omega).$$

$$a = \frac{q}{1 - e^2}.$$

From these the geometrical elements of the orbit were computed. The values of P and T were obtained by another method.

The following are the resulting elements, which must be considered as provisional until further measures are available:—

Elements of Sirius.

P = 58·47 years	Ω = 49° 59′ (1880·0)
T = 1896·47	λ = 216° 18′
e = 0·4055	a = 8″·58
i = 55° 23′	μ = −6°·156

Assuming Gyldén's parallax for *Sirius*, 0″·193, the above values of P and a give

Sum of masses = 26·298 (Sun's mass = 1)
Mean distance = 44·45 (Earth's mean distance from Sun = 1)

The following is a comparison between the recorded measures and the positions computed from the above elements. The

observed position-angles have been corrected for the effect of precession to 1880·0.

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
1862·08	A. Clark	85° ±	85°·23	° ...	10″	9″·03	+0″·97
1862·19	Bond	84·7	84·93	−0·23	10·07	9·07	+1·00
1862·2	Rutherford	85·1	84·90	+0·20	...	...	...
1862·2	Chacornac	84·7	84·90	−0·20	...	...	...
1862·23	Challis	85·1	84·82	+0·28	10·42	9·08	+1·34
1862·28	Lassell	84·0	84·68	−0·68	...	...	...
1863·08	Mitchell	78·6	82·47	−3·87	10·5	9·38	+1·12
1863·10	Rutherford	81·3	82·42	−1·12	...	9·38	...
1863·14	Marth	79·4	82·31	−2·91	10·60	9·39	+1·21
1863·15	Mitchell	79·7	82·29	−2·59	10·9	9·39	+1·51
1863·20	,,	79·3	82·16	−2·86	10·40	9·41	+0·99
1863·21	O. Struve	82·6	82·13	+0·47	10·14	9·41	+0·73
1863·23	Dawes	84·91	82·08	+2·83	10·0	9·42	+0·58
1863·24	Winnecke	79·8	82·06	−2·26	...	9·42	...
1863·27	Bond	82·9	81·98	+0·92	...	9·42	...
1864·15	Lassell	80·4	79·70	+0·70	9·53	9·70	−0·17
1864·21	,,	80·2	79·57	+0·63	9·67	9·72	−0·05
1864·22	O. Struve	79·6	79·54	+0·06	10·92	9·72	+1·20
1865·20	,,	77·3	77·32	−0·02	10·60	10·02	+0·58
1865·22	Forster	78·0	77·27	+0·73	10·78	10·02	+0·76
1865·24	Struve	73·8	77·22	−3·42	10·79	10·02	+0·77
1865·25	Tietjen	76·9	77·19	−0·29	...	10·03	...
1865·26	Engelmann	77·0	77·16	−0·16	9·0	10·03	−1·03
1865·26	Bond	76·1	77·16	−0·06	9·0	10·03	−1·03
1865·70	Struve	73·38	76·0	−2·62	12·91	10·13	(+2·78)
1866·08	Knott	77·18	75·14	+2·04	10·43	10·25	+0·18
1866·20	Tietjen	76·88	74·87	+2·01	10·97	10·28	+0·69
1866·20	Bruhns	...	74·87	...	10·74	10·28	+0·46
1866·20	O. Struve	75·28	74·87	+0·41	10·93	10·28	+0·65
1866·23	Wash. Obs.	74·38	74·81	−0·43	10·21	10·28	−0·07
1866·25	,,	74·38	74·77	−0·39	10·65	10·27	+0·38
1867·22	O. Struve	72·17	72·71	−0·54	10·98	10·52	+0·46
1867·24	Forster	72·37	72·67	−0·30	...	10·52	...
1868·24	Bruhns	69·57	70·54	−0·97	11·35	10·70	+0·65
1868·26	Engelmann	71·67	70·50	+1·17	10·95	10·70	+0·25
1869·10	Brünnow	74·76	68·81	(+5·95)	11·26	10·88	+0·38
1869·15	Vogel	73·66	68·72	(+4·94)	11·23	10·88	+0·35

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
1869·20	Dunér	68°·76	68°·62	+0°·14	11″·17	10″·89	+0″·28
1871·22	„	64·15	64·71	−0·56	10·92	11·15	−0·23
1871·25	Pechule	60·15	64·64	(−4·49)	12·10	11·15	+0·95
1872·18	Dunér	59·84	62·56	−2·72	11·0	11·24	−0·24
1872·24	Wash. Obs.	62·74	62·43	+0·31	11·55	11·24	+0·31
1873·22	Dunér	60·84	60·97	−0·13	10·57	11·27	−0·70
1874·14	Wash. Obs.	58·03	59·27	−1·24	11·39	11·26	+0·13
1875·19	Dunér	57·13	57·32	−0·19	10·73	11·21	−0·48
1875·23	Wash. Obs.	56·23	57·24	−1·01	11·47	11·21	+0·26
1877·17	„	52·81	53·55	−0·74	11·35	11·00	+0·35
1877·25	„	53·41	53·40	+0·01	10·95	10·98	−0·03
1877·93	Burnham	53·21	52·06	+1·15	10·71	10·83	−0·12
1877·97	„	52·41	51·98	+0·43	10·83	10·82	+0·01
1878·03	„	51·11	51·86	−0·75	...	10·81	...
1879·05	„	50·7	49·77	+0·93	10·44	10·62	−0·18
1879·75	Cinn. Obs.	46·5	48·30	−1·8	10·29	10·44	−0·15
1880·11	Burnham	48·3	47·42	+0·88	10·00	10·27	−0·27
1880·168	Hough	49·6	47·29	+2·31	9·87	10·26	−0·39
1881·07	Burnham	46·3	45·32	+0·98	9·77	10·01	−0·24
1881·12	Holden	43·3	45·20	−1·90	10·83	9·99	+0·84
1881·26	Wash. Obs.	45·3	44·86	+0·44	10·0	9·94	+0·06
1881·26	Hough	45·3	44·86	+0·44	9·60	9·94	−0·34
1881·99	Burnham	43·6	43·09	+0·51	9·38	9·67	−0·29
1882·127	Hough	43·1	42·75	+0·35	9·30	9·61	−0·31
1882·183	Frisby	42·24	42·61	−0·37	9·955	9·58	+0·375
1882·235	Hall	42·48	42·48	0·0	9·668	9·57	+0·098
1883·10	Young	38·99	40·67	−1·68	9·41	9·21	+0·20
1883·12	Hough	39·68	40·60	−0·92	9·02	9·20	−0·18
1883·17	Frisby	41·41	40·43	+0·98	9·754	9·17	+0·584
1883·211	Hall	39·08	40·29	−1·21	9·260	9·15	+0·11
1884·05	Hough	35·98	37·37	−1·39	9·67	8·72	+0·95
1884·179	„	36·68	36·98	−0·30	8·51	8·65	−0·14
1884·19	Burnham	36·38	36·95	−0·57	8·39	8·64	−0·25
1884·226	Hall	37·64	36·83	+0·81	8·81	8·62	+0·19
1884·273	Young	36·28	36·70	−0·42	8·70	8·60	+0·10
1885·11	Paris Obs.	34·07	33·85	+0·22	8·09	8·13	−0·04
1885·112	Young	34·03	33·85	+0·18	8·09	8·13	−0·04
1885·197	Hough	32·67	33·50	−0·83	7·96	8·08	−0·12
1885·268	Hall	34·70	33·25	+0·45	8·057	8·03	+0·027

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
		°	°	°	″	″	″
1885·301	Hall	33·87	33·09	+0·78	7·93	8·01	−0·08
1886·047	Young	29·74	30·26	−0·52	7·59	7·57	+0·02
1886·14	Wash. Obs.	30·57	29·90	+0·67	7·21	7·51	−0·30
1886·144	Hough	28·67	29·88	−1·21	7·21	7·51	−0·30
1886·22	Wash. Obs.	28·66	29·53	−0·87	7·39	7·46	−0·07
1887·14	Young	25·36	25·32	+0·04	7·08	6·84	+0·24
1887·195	Hough	23·66	25·04	−1·38	6·78	6·80	−0·02
1887·238	Hall	24·14	24·82	−0·68	6·508	6·77	−0·262
1888·97	Burnham	13·85	13·96	−0·11	5·27	5·52	−0·25

I have computed the following short ephemeris:—

Epoch.	Position-angle.	Distance.
	°	″
1890·2	2·61	4·62
1891·2	349·68	3·95
1892·2	332·27	3·45
1893·2	310·88	3·23
1894·2	288·95	3·36
1895·2	270·37	3·78
1896·2	255·95	4·24

On the close Conjunction of Mars and Saturn near Regulus on September 19, 1889. By A. Marth.

The conjunction of *Mars* and *Saturn* predicted in the Almanacs for September 19, 20^h G.M.T., deserves special attention. The tabular places of the two planets give the nearest geocentric approach of their centres 54″·8 at $20^h\ 7^m$ Greenwich mean time, so that the conjunction will be a closer one than that of June 30, 1879, when the shortest distance between the nearest limbs was 74″, according to the Melbourne observations, *Monthly Notices*, vol. xl. p. 30. The next close conjunction preceding that of 1879 took place on April 18, 1817, but was not observable at any then existing observatory, and of any previous close conjunction there is at least no record.

The differences of right ascension and declination between *Titan* and *Iapetus* and the centre of *Saturn* will be

		Titan.		*Iapetus.*	
		$\alpha_s-A.$	$\delta_s-D.$	$\alpha_s-A.$	$\delta_s-D.$
	h	s	″	s	″
Sept. 19	16 Gr.	−7·81	−34·6	+11·54	−11·7
	20 „	7·25	35·0	11·12	11·5
20	0 „	−6·66	−35·2	+10·70	−11·3

Hence the geocentric differences between *Mars* and *Iapetus* will be

			$\tau_0 - \alpha_s$	$\tau_0 - \delta_s$
	h	m	s	″
Sept. 19	22	0 Gr.	−0·30	+12·9
		10	+0·54	+ 8·5
	22	20	+1·38	+ 4·1

If these tabular values are not too much in error, observers in America may get the rare chance of observing, if not an actual occultation of *Iapetus* by *Mars*, at least a very close conjunction of the two bodies, which, even as a mere *curiosum*, will be worth attending to.

What renders this year's conjunction between *Mars* and *Saturn* specially remarkable and interesting, is the circumstance that it takes place not far from *Regulus*, the geocentric distance of *Mars* from the star being

	h		′	″		°
Sept. 19	18 Gr.	Distance	47	57·3	Posit.-angle	5·74
	20 „		47	17·0		9·43
	22 „		46	48·8		13·24

and it has seemed to me worth while to examine when such a phenomenon has occurred before. On the occasion of an oral communication made at the June meeting of the Royal Astronomical Society in 1877, I showed some diagrams referring to triple conjunctions between *Mars* and *Saturn*, some of which were reproduced in the report published in the *Astronomical Register*, vol. xv. p. 156 ff. One of these diagrams exhibited the path of *Mars* relative to *Saturn* from November 1742 to June 1743, the third conjunction occurring on May 17, when *Mars* passed *Saturn* at a distance of 10′ to the south. On June 1 this conjunction was followed by a close conjunction between *Mars* and *Jupiter* at a distance of only 72″. Referring to Cassini's paper in the *Paris Memoirs* of 1743, p. 318 ff., and to the graphical representation there given, it will be found that *Regulus* formed with the planets a most interesting constellation, the star being at the time of the conjunction of May 17 only a couple of degrees distant. The planets were then to be seen in the evening.

The conjunction of *Mars* and *Saturn* near *Regulus* most nearly resembling that of the present year, when they are morning stars, must have occurred in the year 1447, but I am not aware that there exists any record of its having been observed. For a long period previous to 1447 no similar close conjunction has occurred.

The interest of the present year's conjunction is enhanced by another circumstance. On September 25 *Venus* will pass *Regulus* at a distance of 11′, and will, in the following week, come into conjunction with *Saturn* and with *Mars*.

If the old Chaldeans were in fact such diligent stargazers as they are sometimes represented, they must have been watchful in observing conjunctions of the planets with one another and with fixed stars, such as are to be found in the records of Chinese and of Arabian observers, which have been made accessible to us by Gaubil and by Caussin. The cuneiform inscriptions have not yet yielded up the secreted records of such observations, which would be of essential service in settling questions of their chronology. Perhaps some day the old Chaldean observations may yet be made accessible. But I doubt whether, however far they may go back, there will be found in them a combination of conjunctions resembling that of next September; for I question whether, since the beginning of Scaliger's Julian period or during the last six thousand years, any year can be found in which this special combination of conjunctions has occurred. Hence it will be worth while to be on the alert to observe it. And useful observations may be made with the naked eye. In the old records are found apparent occultations of *Mars* and of *Jupiter* by *Venus*, of *Jupiter* by *Mars*, of *Regulus* by *Venus* and by *Jupiter*, &c., but it is uncertain what are the limits of distance within which such bright bodies appear to the naked eye as one. Though no apparent occultation of *Saturn* by *Mars* is on record, the careful watching of the two planets and noting the times when, without undue straining of the eyes, they cease to appear separated, and when they begin again to appear so, will be of service in correctly interpreting the old observations. On September 19 the geocentric distance of their centres will be

	h	m		h	m	
within 2′ from	18	44	to	21	30	Gr. m. t.
3′ „	17	53	„	22	20	
4′ „	17	4	„	23	9	
5′ „	16	16	„	23	57	

As the planets are only 30° from the Sun, the beginning and ending of the apparent occultation cannot be observed from the same place. But, as any trustworthy schoolboy or schoolgirl may be entrusted with taking part in the watching, there ought to be no lack of numerous observers of the phenomenon in favoured terrestrial longitudes. The opportunity may also be taken to watch when the planets and *Regulus* cease to be visible in the morning twilight, and by repeating the watching and observing the altered positions of the three planets and of the star on the following mornings to gain some instructive astronomical knowledge.

On the Eclipse of Iapetus by Saturn and its Ring-System, on November 1–2, 1889. By A. Marth.

The inclination of the orbit of *Iapetus* to the plane of the ring being nearly 14°, while the orbits of the other satellites have inclinations of less than 1°, the rare eclipses of *Iapetus* by the ring-system offer the only chance of deciding several questions which may be settled with the help of observed eclipses. No such observation has ever yet been made. Favourably-placed observers ought, therefore, to take full advantage of the rare chance they may get on November 1. There will not be another such chance for at least the next sixteen years.

The geocentric differences of right ascension and declination between *Titan* and *Iapetus* and the centre of *Saturn* will be from October 24 to November 4.

	Titan.		*Iapetus.*	
Greenwich Noon.	$\alpha_c - A.$	$\delta_c - D.$	$\alpha_c - A.$	$\delta_c - D.$
	s	″	s	″
Oct. 24	+ 1·60	−24·5	−23·73	+28·6
25	+ 5·90	−14·5	−21·79	+28·3
26	+ 9·31	− 2·4	−19·72	+27·8
27	+11·26	+10·0	−17·53	+27·2
28	+11·39	+20·8	−15·24	+26·4
29	+ 9·64	+28·1	−12·85	+25·4
30	+ 6·29	+30·7	−10·38	+24·3
31	+ 1·88	+28·2	− 7·84	+23·0
Nov. 1	− 2·84	+21·1	− 5·25	+21·5
2	− 7·14	+10·8	− 2·62	+19·9
3	−10·37	− 1·3	+ 0·04	+18·1
4	−12·09	−13·1	+ 2·70	+16·3

These values show that, while the Earth is still on the south side of the plane of the orbit of *Titan*, it has already passed through the plane of the orbit of *Iapetus*, and is on the north side of that plane. Hence *Titan* and *Iapetus*, though both being north of the planet, move apparently in opposite directions, *Titan* being in front of the planet, or near inferior conjunction, while *Iapetus* is beyond the planet, or near superior conjunction. On October 31, at $10^h{\cdot}5$ G.M.T., *Titan* passes in the direction of the minor axis of the ring at a distance of 26″ to the north. On November 1, at $8^h{\cdot}0$ G.M.T., *Iapetus* encounters

Titan, and passes at a distance of 3″. Not long after this conjunction, between 9h and 10h, *Iapetus* enters the shadow of the ring-system, from which it will emerge between 4h and 5h on November 2. As I am very desirous not to give more precise predictions which might be misleading, I will let interested readers judge for themselves by furnishing them with the data for constructing a diagram, which will show them the sources of uncertainty in predicting the times at a glance.

The section of the shadow, through which *Iapetus* has to pass, consists of a series of ellipses, corresponding to the outer and inner rims, A*a*, B*b*, C*c*, of the three rings, and to the outline of the ball. The heliocentric semi-axes of these ellipses, corresponding to various determinations of the dimensions of the rings and of the ball, are at the time of the eclipse:

	Major Semi-axis.	Minor Semi-axis.			Major Semi-axis.	Minor Semi-axis.	
	″	″			″	″	
A	20·76	4·03	W. Struve	*b*	13·79	2·67	W. S.
	20·33	3·94	Bessel		12·87	2·50	O. S.
a	18·25	3·54	W. S.	*c*	10·99	2·13	Bond
	18·16	3·52	O. Struve		10·76	2·09	O. S.
B	17·82	3·46	W. S.	ball	9·30	...	W. S.
	17·62	3·42	O. S.		8·22	8·00	Bessel

The computed heliocentric co-ordinates of *Iapetus*, referred to the axes of the ring, and corresponding to the lines when light from the satellite arrives at the Earth, are:

	h				h		
Nov. 1	8 Gr.	−16″·08	+3″·32	Nov. 1	20 Gr.	+4″·08	+0″·45
	12	− 9·36	+2·37	2	0	+10·80	−0·50
	16	− 2·64	+1·41		4	+17·52	−1·46
	20	+ 4·08	+0·45		8	+24·23	−2·41

What corrections these values may require I am unable to suggest. If I were acquainted with the observations of the satellite made during the last opposition, and could determine the errors of the last ephemeris, I might get nearer the truth. But it is clear that as an error of 1″ in the heliocentric longitude of the satellite corresponds to an error of 36 minutes in the time, considerable uncertainty must attach to any predicted times, to which the other sources of doubt add their share.

When used with the necessary caution of making proper allowance for this uncertainty, the following times may serve as a guide in preparing for the observations to be made:

	h				
Nov. 1	8·0	Gr. Iap. & Tit.			
	9·4	„	Disappearance	A	W. S.
	9·6	„	„	„	Bessel
	10·6	„	? Reappearance	*a*	W. S.
	10·9	„	D.	B	O. S.
	22·8	„	R. from shadow of ball		Bessel
	23·1	„	„ „		W. S.
	23·8	„	enters shadow of crape ring.		
Nov. 2	1·4	„	D.	*b*	W. S.
	3·2	„	? R.	B	O. S.
	3·5	„	D.	*a*	W. S.
	4·5	„	R.	A	Bessel
	4·7	„	„	„	W. S.

Will *Iapetus* be visible when Cassini's division *a*B is between the satellite and the Sun? What will be the effect of the shadow of the crape ring upon the appearance of the satellite?

Favourably-placed observers will have to answer such questions by their watching the satellite, and their time will be well spent in doing so.